# Weather Note

## THE MIDDLE MISSISSIPPI VALLEY HYDROMETEOROLOGICAL STORM OF MAY 4–9, 1961

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### 1. INTRODUCTION

A hydrometeorological storm of major importance occurred over the middle Mississippi Valley, mainly from eastern Oklahoma and eastern Kansas eastward into the Ohio Valley, during the period May 4–9, 1961. Flooding from the heavy rainfall ranged from the flashtype to large-scale overflow. Approximately ten fatalities were attributed to the heavy rain and flooding. Total evaluation of property damage is yet to be completed, but preliminary estimates of damage are in the millions of dollars. The magnitude of the storm is evident from figure 1A which is the smoothed analysis of total storm rainfall, as reported by selected stations during the 6-day period ending 1200 GMT May 9.

This note presents a short description of the surface and 500-mb. features of the storm, the vertical motions as computed by the warm-air advection method used by the Quantitative Precipitation Forecasting (QPF) Unit of the National Meteorological Center, and the Unit's operational, 24-hour, quantitative forecasts and their verification. A composite storm forecast and verification is given, since in larger river basins precipitation in successive 24-hour periods becomes increasingly important.

### 2. SYNOPTIC SITUATION

The May 3–9 series of 1200 GMT synoptic surface and 500-mb. charts is shown in figures 2–8. Observed precipitable water analyzed for increments of 0.25 inch and the observed 1-inch isohyet for the 24 hours prior to map time are superimposed on the surface charts. Computed average vertical motions for the 1000–500-mb. layer are superimposed on the 500-mb. charts.

The 500-mb. chart on May 3 (fig. 2B), immediately preceding the outbreak of the heavy precipitation, showed the long-wave trough position established over the western States. This position was maintained during the first half of the period, but on May 7 (fig. 6B) an eastward shift commenced and, by May 9 (fig. 8B) the long-wave trough had advanced to the Mississippi River. Prior to its displacement eastward, three short-wave troughs had moved through the long-wave trough and into the Central Plains.

The surface charts show only three distinct systems over the central United States during this period. The first surface Low, already established over the Panhandles of Texas and Oklahoma on the 3d (fig. 2A), remained nearly stationary for the first 48 hours. It then moved northeastward decreasing in intensity and becoming only a weak wave off the New England coast on May 8 (fig. 7A). The second surface Low formed rapidly over Kansas on the 7th (fig. 6A) and immediately moved northeastward through the Great Lakes. The final surface system formed as a wave on the front in Oklahoma on the 8th (fig. 7A) and moved on a northeastward course a little south of its predecessors.

### 3. VERTICAL MOTIONS

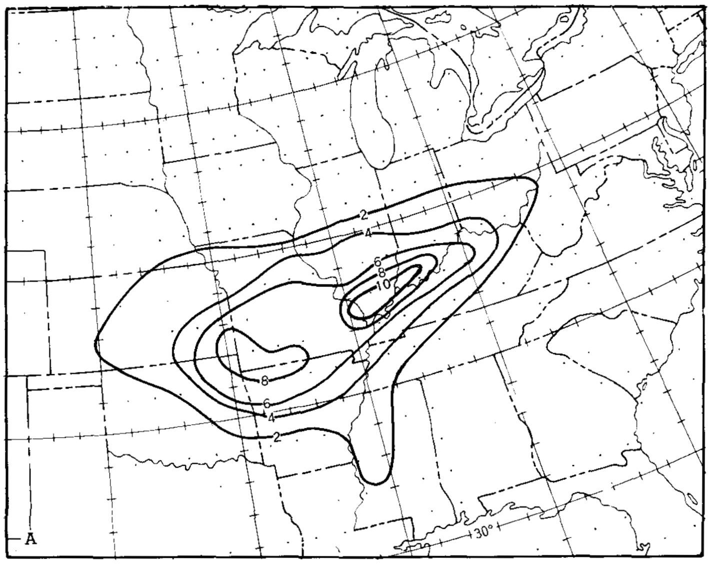
The vertical motions used by the QPF Unit are computed by a technique based primarily on the indicated rate of warm advection.* The precipitation rate was established by statistically relating the indicated rate of warm advection, the available moisture, and the observed precipitation. Conversion to cm. sec.$^{-1}$ was accomplished by a comparison of the indicated rate of warm advection and the vertical motion required to produce equal precipitation rates.

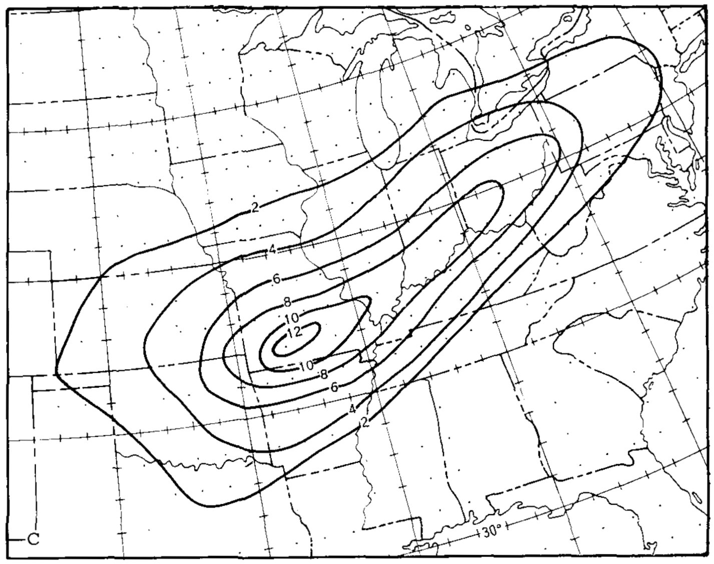
The indicated rate of warm advection is obtained operationally using the 1000–500-mb. thickness ($Z_5$) to describe the thermal field and the 1000-mb. geostrophic wind ($\mathbf{V}_0$), the wind field. The resultant vertical motion ($W$), which is a mean value for the 1000–500-mb. layer, is given by $W=C\ (\mathbf{V}_0 \cdot \nabla Z_5)$ where $C$ is constant.

The vertical motions shown in the accompanying figures were obtained during routine operation which makes use of the Radat 500-mb. chart, available much earlier than the regularly analyzed 500-mb. charts reproduced here. Only positive vertical motions were computed, since negative motions are unimportant to QPF.

On the first day of the period (fig. 2B), centers of positive vertical motion were over the Oklahoma Panhandle region and over southern Nevada. The eastern center lacked upper-air support and consequently failed to move

*More detailed descriptions of the operational computation of the vertical velocities, and of the QPF technique used by the Unit, have been included in the "Synoptic Meteorological Practices at the National Weather Analysis Center, Part II," which is expected to be available late in 1961.



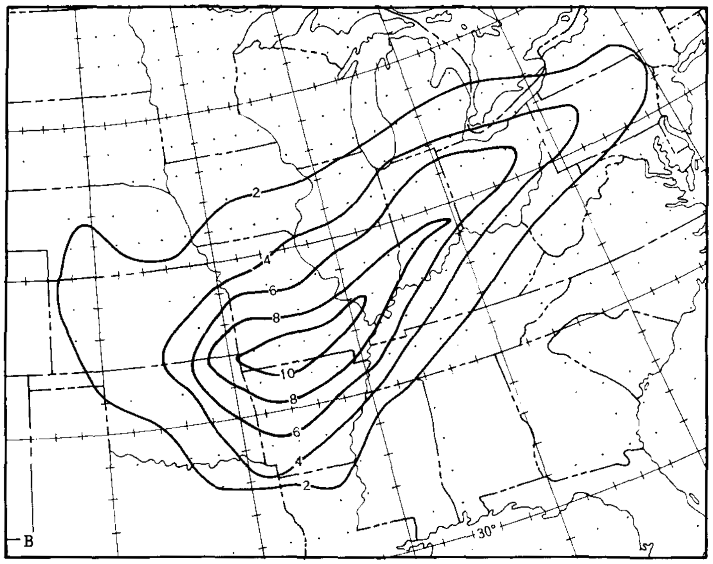




FIGURE 1.—(A) Total storm precipitation observed during the 6-day period from 1200 GMT May 3 to 1200 GMT May 9, 1961. (B) Total precipitation forecast by the Early QPF for the 6-day period. (C) Total precipitation forecast by the Revised QPF during the 6-day period.

during the ensuing 24 hours, but the one to the west moved eastward and combined with the center over Oklahoma. This appeared on May 5 (fig. 4B) to be the same center over southern Kansas, but a closer inspection of the vertical motion gradients indicate that that center had actually weakened and moved to Illinois and Iowa while a weak vertical motion area that had been over eastern Nevada reinforced the area of vertical motion to the east. At this time two other positive vertical motion areas were visible as they swung around the long-wave trough position. These two areas moved little during the next 24 hours while the area to the east moved on eastward, weakened, and became disorganized (fig. 5b). A drastic change in the vertical motion pattern had occurred by May 7 (fig. 6B) with the center over southwestern United States moving into Kansas and being replaced by the area that had been along the west coast. By May 8 (fig. 7B), the Kansas center had moved over the Great Lakes and again weakened as it did so, while the one in the Southwest had moved to northeastern Oklahoma. This latter center proved to be the last of the series and the final chart (fig. 8B) shows its eastward progression.

## 4. MOISTURE

The precipitable water, representing the moisture field in figures 2A–8A, is a measure of the moisture available to the precipitation process rather than an indicator of the location of the precipitation occurrence. Inspection shows that the 24-hour 1-inch precipitation amounts occurred in areas where the precipitable water values reached at least 0.75 inch sometime during the period, and that the larger amounts generally were associated with precipitable water areas of over 1 inch.

## 5. FORECASTS

The Quantitative Precipitation Forecasting Unit has

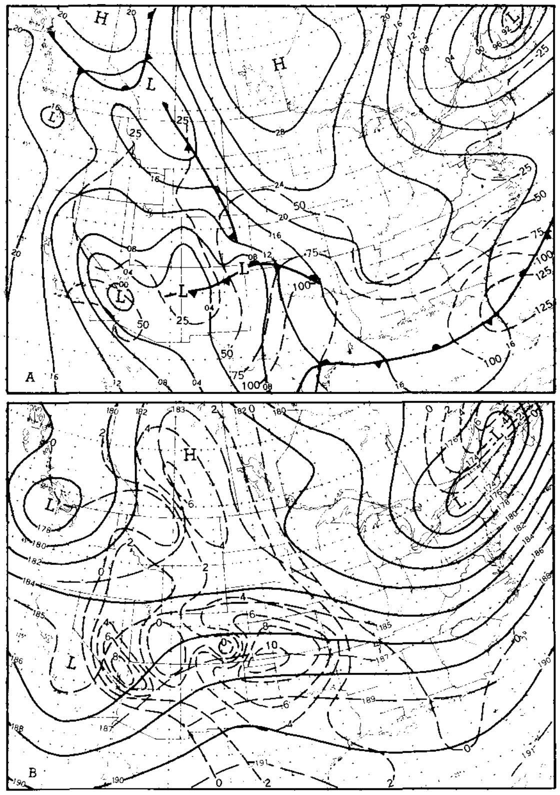


FIGURE 2.—(A) Surface (solid lines) and precipitable water (dashed lines) analyses, 1200 GMT, May 3, 1961. (B) Analyzed 500-mb. contours (solid lines) and computed positive vertical velocities (dashed lines) 1200 GMT May 3, 1961.

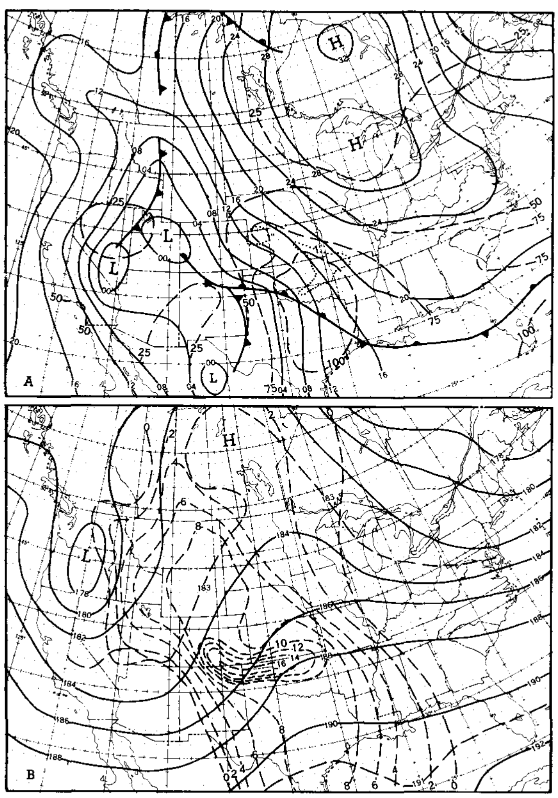


FIGURE 3.—(A) Surface (solid lines) and precipitable water (dashed lines) analyses 1200 GMT, May 4, 1961 with 1-inch isohyets (dotted lines) observed during the preceding 24 hours. (B) Same as figure 2B, but for 1200 GMT, May 4, 1961.

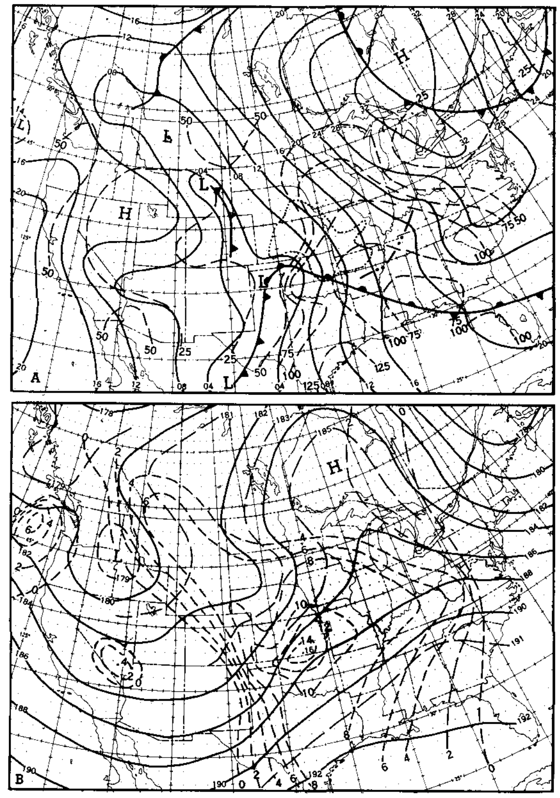


FIGURE 4.—(A) Surface (solid lines) and precipitable water (dashed lines) analyses 1200 GMT, May 5, 1961 with 1-inch isohyets (dotted lines) observed during the preceding 24 hours. (B) Analyzed 500-mb. contours (solid lines) and computed positive vertical velocities (dashed lines) 1200 GMT, May 5, 1961.

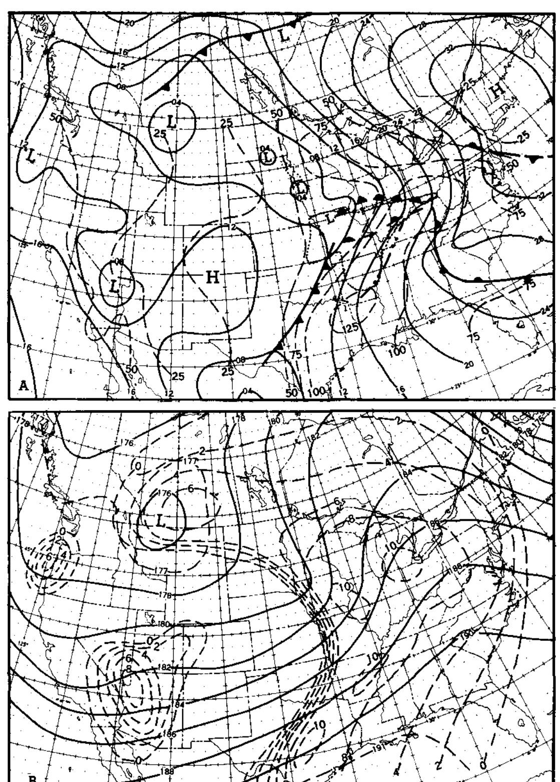


FIGURE 5.—Same analyses as in figure 4 but for 1200 GMT, May 6, 1961.

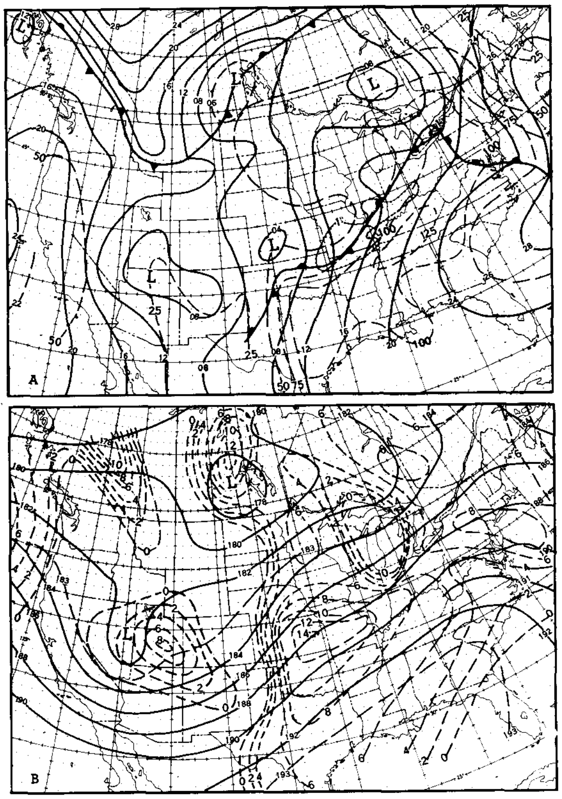


FIGURE 6.—(A) Surface (solid lines) and precipitable water (dashed lines) analyses 1200 GMT, May 7, 1961 with 1-inch isohyets (dotted lines) observed during the preceding 24 hours. (B) Analyzed 500-mb. contours (solid lines) and computed positive vertical velocities (dashed lines) 1200 GMT, May 7, 1961.

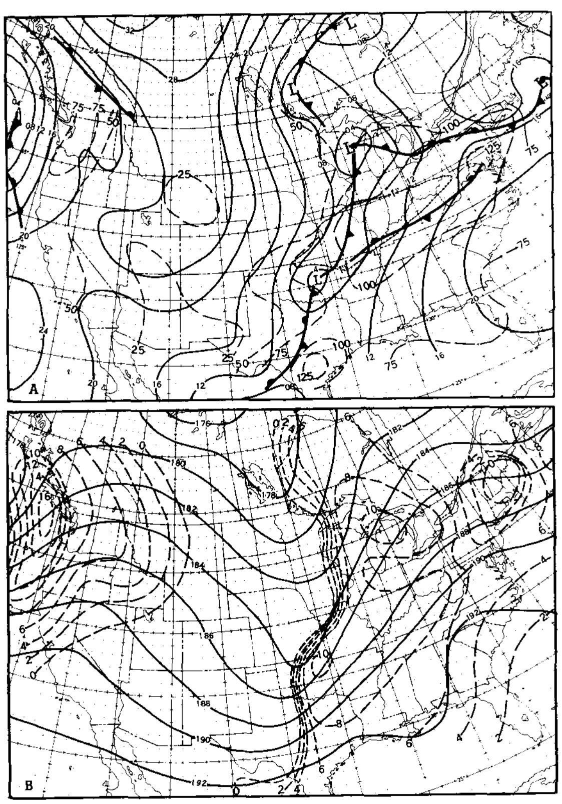


FIGURE 7.—Same analyses as in figure 6 but for 1200 GMT, May 8, 1961.

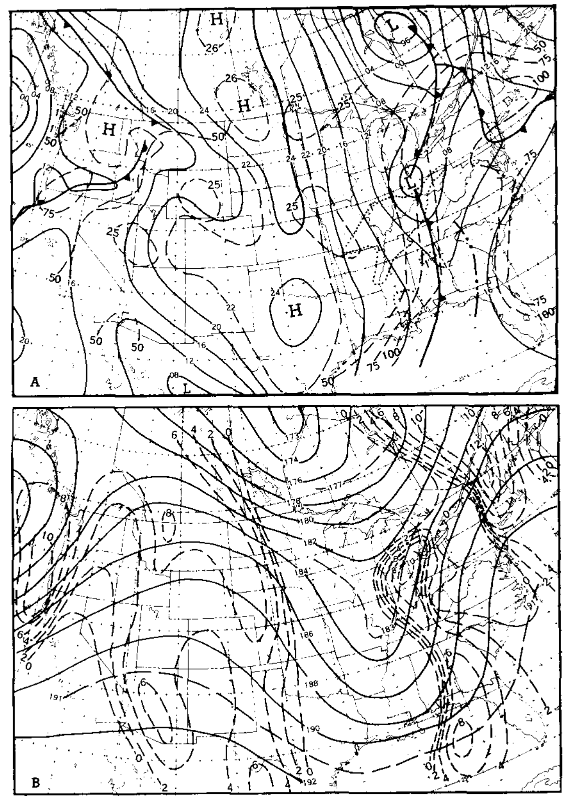


FIGURE 8.—(A) Surface (solid lines) and precipitable water (dashed lines) analyses 1200 GMT May 9, 1961 with 1-inch isohyets (dotted lines) observed during the preceding 24 hours. (B) Analyzed 500-mb. contours (solid lines) and computed positive vertical velocities (dashed lines) 1200 GMT, May 9, 1961.

responsibility for general guidance of other Weather Bureau offices, over the nation, in their 24-hour quantitative precipitation forecasts. Forecasts are issued twice daily by the Unit for the period 1200 GMT to 1200 GMT. The first forecast, which is referred to as the "Early Forecast," is issued at approximately 1200 GMT and the second, the "Revised Forecast," is issued at approximately 1700 GMT.

Daily 24-hour forecasts of precipitation amounts for selected stations were totaled over the storm period. These were analyzed to give a smooth isohyetal pattern (fig. 1B, C) of total forecast precipitation for the storm. An areal verification was then made of the total forecast against the total observed. The area forecast ($A_f$), the area observed ($A_0$), and the area correct ($A_c$) were measured with a planimeter. Having done this, it is a simple matter to obtain the "prefigurence," $A_c/A_f$, the "post-agreement," $A_c/A_0$, and the "threat score," $A_c/[(A_f-A_c)+(A_0-A_c)+A_c]$. The "prefigurence" is simply that portion of the area correctly forecast compared to the total area forecast, while the "post-agreement" compares the area correctly forecast to the total area observed. The "threat score" compares the area correctly forecast to the total area forecast and observed. Therefore a perfect forecast has a "threat score" of 1.00. These verification results are given in table 1.

TABLE 1.—*Verification scores of forecast precipitation amounts totaled for the storm period of 1200 GMT, May 3 to 1200 GMT, May 9, 1961. The Early Forecast refers to the one issued at approximately 1200 GMT and the revised to the one issued at 1700 GMT.*

| EARLY FORECAST | | | | REVISED FORECAST | | | |
|---|---|---|---|---|---|---|---|
| Amount (in.) | Prefigurence | Post-Agreement | Threat Score | Amount (in.) | Prefigurence | Post-Agreement | Threat Score |
| 2.00 | 0.54 | 0.99 | 0.53 | 2.00 | 0.51 | 0.97 | 0.50 |
| 4.00 | .55 | .95 | .53 | 4.00 | .49 | 1.00 | .49 |
| 6.00 | .50 | .92 | .48 | 6.00 | .56 | 1.00 | .55 |
| 8.00 | .39 | .80 | .35 | 8.00 | .35 | .95 | .34 |
| 10.00 | .09 | .19 | .06 | 10.00 | .06 | .19 | .05 |
| | | | | 12.00 | 0 | 0 | 0 |

TABLE 2.—*Average verification scores of forecast daily precipitation amounts (period ending 1200 GMT) for the storm of May 4–9, 1961. The Early Forecast refers to the one issued at approximately 1200 GMT and the revised to the one issued at 1700 GMT.*

| EARLY FORECAST | | | | REVISED FORECAST | | | |
|---|---|---|---|---|---|---|---|
| Amount (in.) | Prefigurence | Post-Agreement | Threat Score | Amount (in.) | Prefigurence | Post-Agreement | Threat Score |
| 1.00 | 0.41 | 0.74 | 0.37 | 1.00 | 0.40 | 0.79 | 0.36 |
| 2.00 | .19 | .44 | .15 | 2.00 | .25 | .73 | .23 |
| 3.00 | .01 | .04 | .01 | 3.00 | .05 | .18 | .04 |
| 4.00 | 0 | 0 | 0 | 4.00 | 0 | 0 | 0 |

The averages of the daily scores for the same period (table 2) were, as might be expected, lower than the scores for the overall storm. In this particular 6-day period there was little difference in the scores between the Early Forecast and the Revised Forecast on either an overall storm basis or the daily average basis. However, a review of the monthly scores since October 1960 shows an average improvement in the threat score from the Early Forecast to the Revised Forecast for the 1-inch isohyetal of 0.07. This is a significant improvement and is a result of a more accurate description of the vertical motion and moisture fields at the beginning of the period through the use of 1200 GMT data, and the improved surface and upper-air prognosis possible over a shorter time period.

It is encouraging that the QPF's based on the semi-objective use of warm air advection and precipitable water have been as satisfactory as they have. Further progress may be expected as numerical methods increase their contribution to more refined prognostics.

## ACKNOWLEDGMENTS

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